Updated Aerosol Climatology for Cape Point, South Africa

C. Labuschagne, E-G. Brunke
South African Weather Service

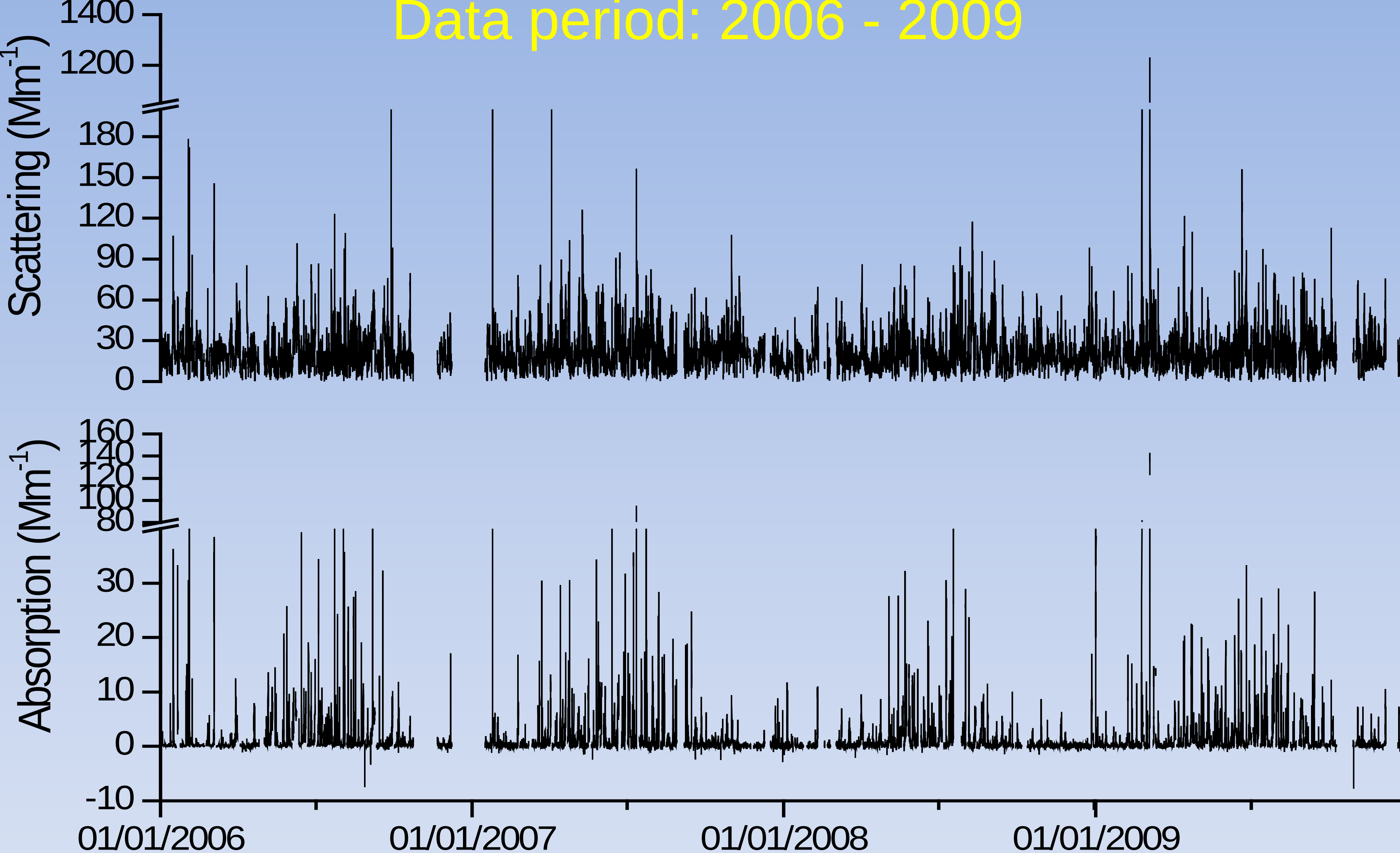
E. Andrews, J.A. Ogren, P.J. Sheridan
NOAA ESRL

Aerosol sampling & analysis

South African Weather Service

NOAA ESRL Global Monitoring Division

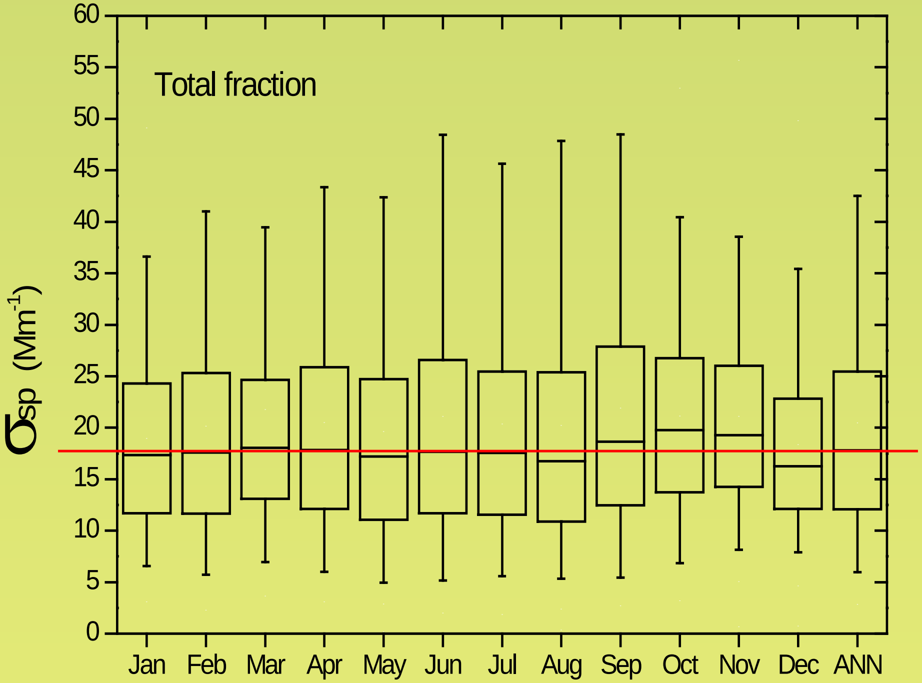
Data period: 2006 - 2009

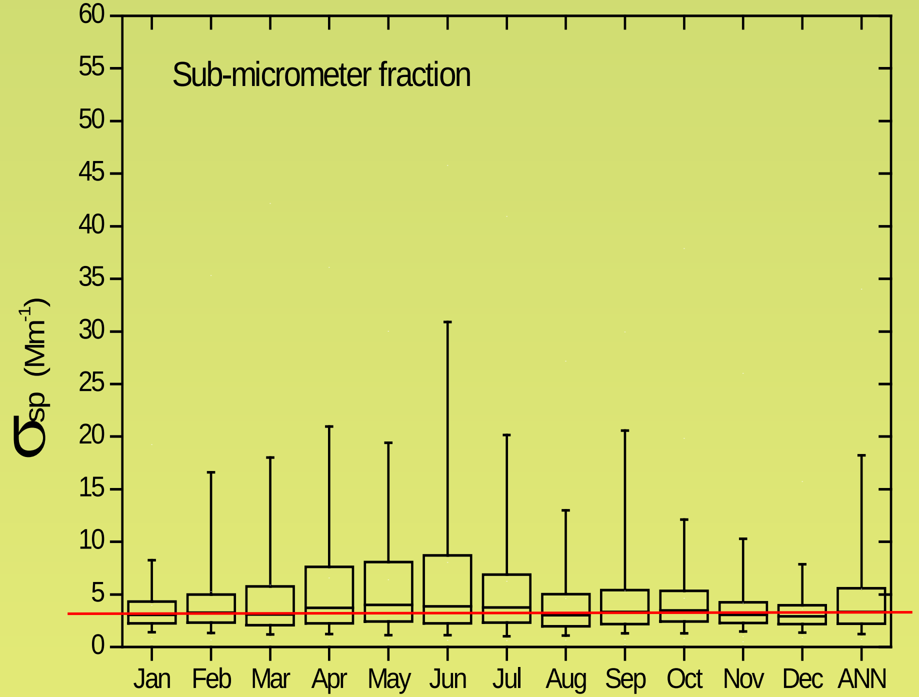


"In the Lord we trust…. all others must provide data!"

anonymous

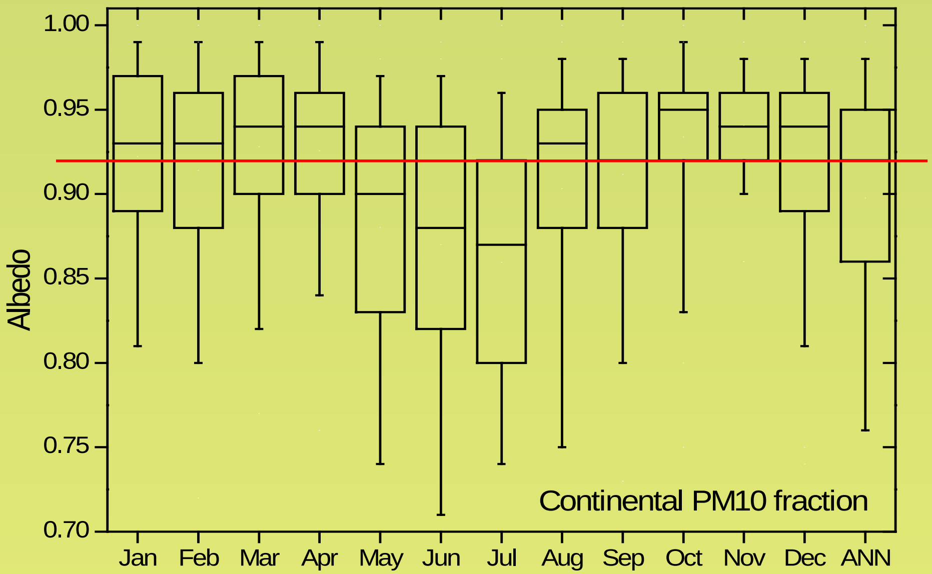
Aerosol scattering (σ_{sp})

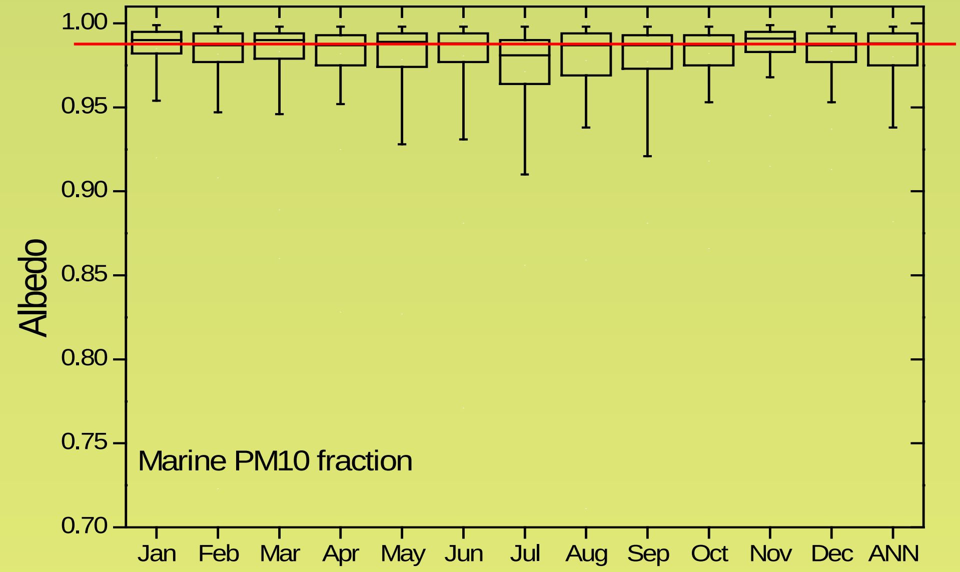




- Seasonal pattern is discernable in sub-µm data, contrasting the total fraction
- Annual mean aerosol scattering of PM10 fraction is 6x higher than PM1 fraction
- For the PM1 fraction, Summer months (DJF) have the least variation in aerosol light scattering (2 – 4 Mm^{-1}) – highest wind speeds; mainly from south (marine organic particles & predominantly sea salt particles?)
- Late Autumn - Winter months (MJJA) are dominated by urban particles; also evident in ω and ấ

Single Scattering Albedo (ω_0): Continental vs Marine fraction

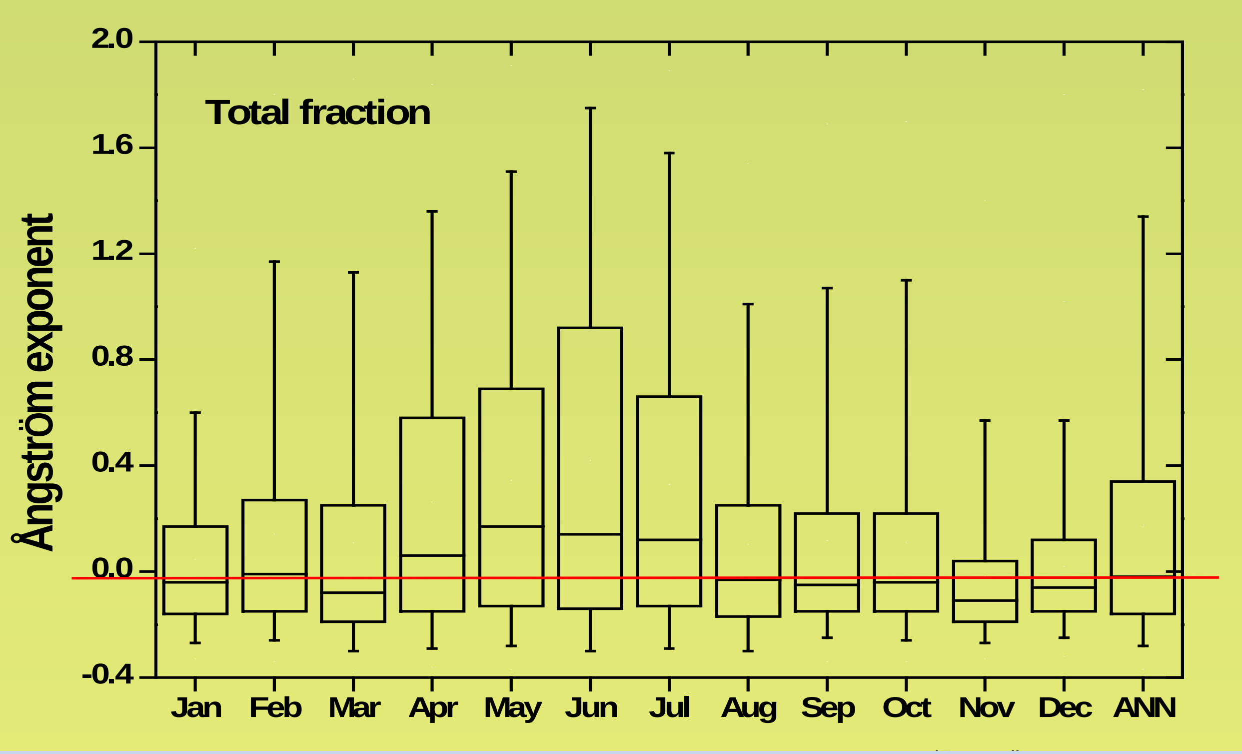




- Continental = ^{222}Rn > 1200 mBeq/m^3 Marine = ^{222}Rn < 350 mBeq/m^3
- Both Continental & Marine albedo fractions display an annual cycle
- Continental annual mean ω_0 ~0.92 compared to ~0.99 for marine
- Marine fraction – generally, most of seasonal variation is in the 5th – 25th percentile of data compared to 5th – 95th percentile of Continental fraction
- From May – Sep, Continental albedo fraction contains Urban signal & instances of Biomass burning (resulting in higher amounts of absorbing aerosols)
- Complex to decipher when considering ω_0 alone – deal with frontal systems as well as incidences of inversion trapping of pollutants

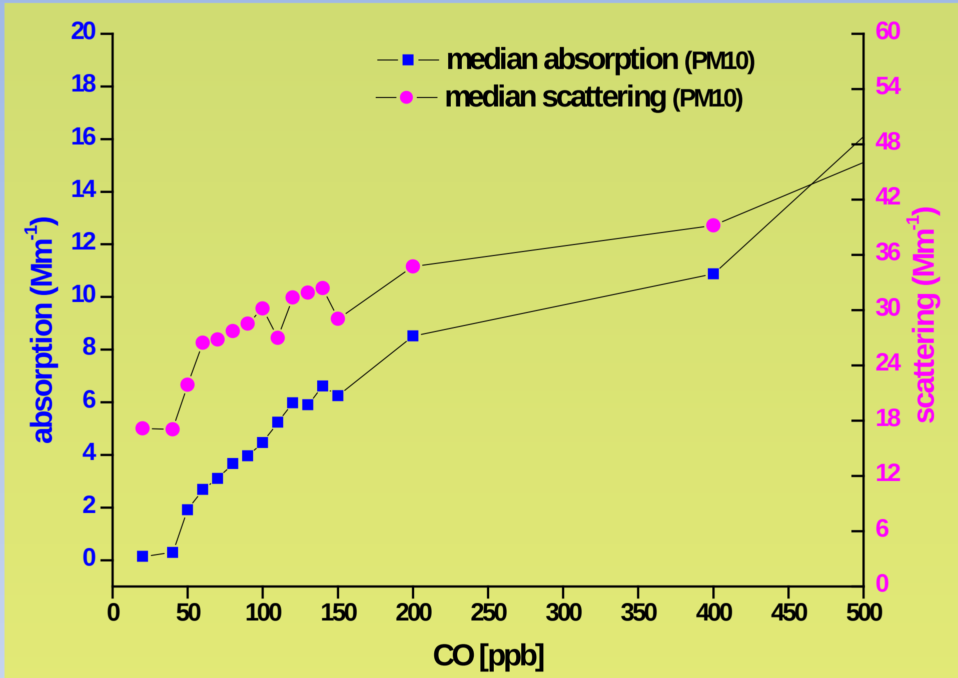
South African Weather Service

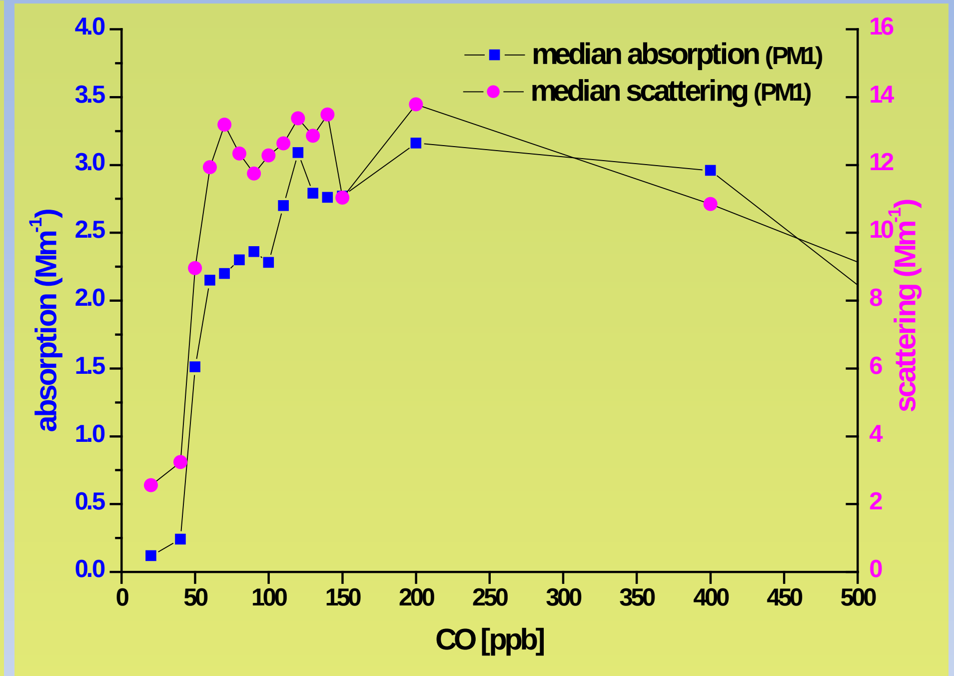
Ångström exp (å) 550/700 nm – PM10 fraction



- Smaller å indicative of large particles & bigger å indicate smaller particle sizes
- Strong evidence of a seasonal pattern in data set
- Smaller particles dominate in late autumn - winter months (AMJJ when mean å > 0) & larger particles in summer season (NDJFM) when mean å ≤ 0 (mainly sea-salt dominance)
- Strongest seasonal pattern observed in the 75th - 95th percentile data

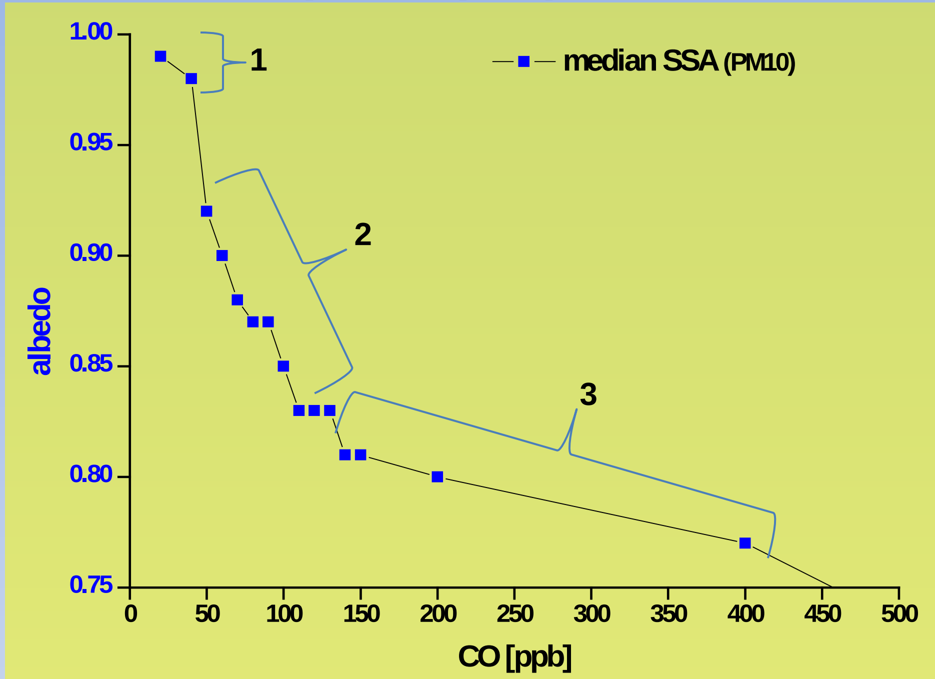
Aerosol optical properties as f(x) of Carbon monoxide distribution

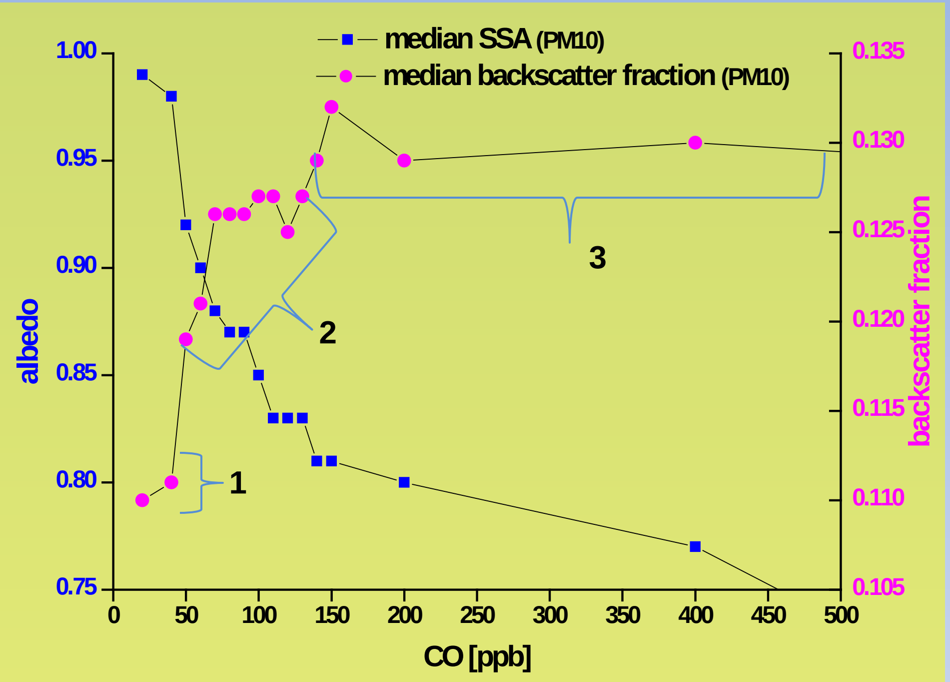




- CO is a good indicator of anthropogenic influence(s): at CPT baseline CO ranges from 40 – 70 ppb
- Both absorption and scattering follows similar increases with increasing [CO]
- For the sub-μm data – sudden increase in absorption & scattering as CO increase above 70 ppb

Aerosol optical properties as f(x) of Carbon monoxide distribution (cont.)

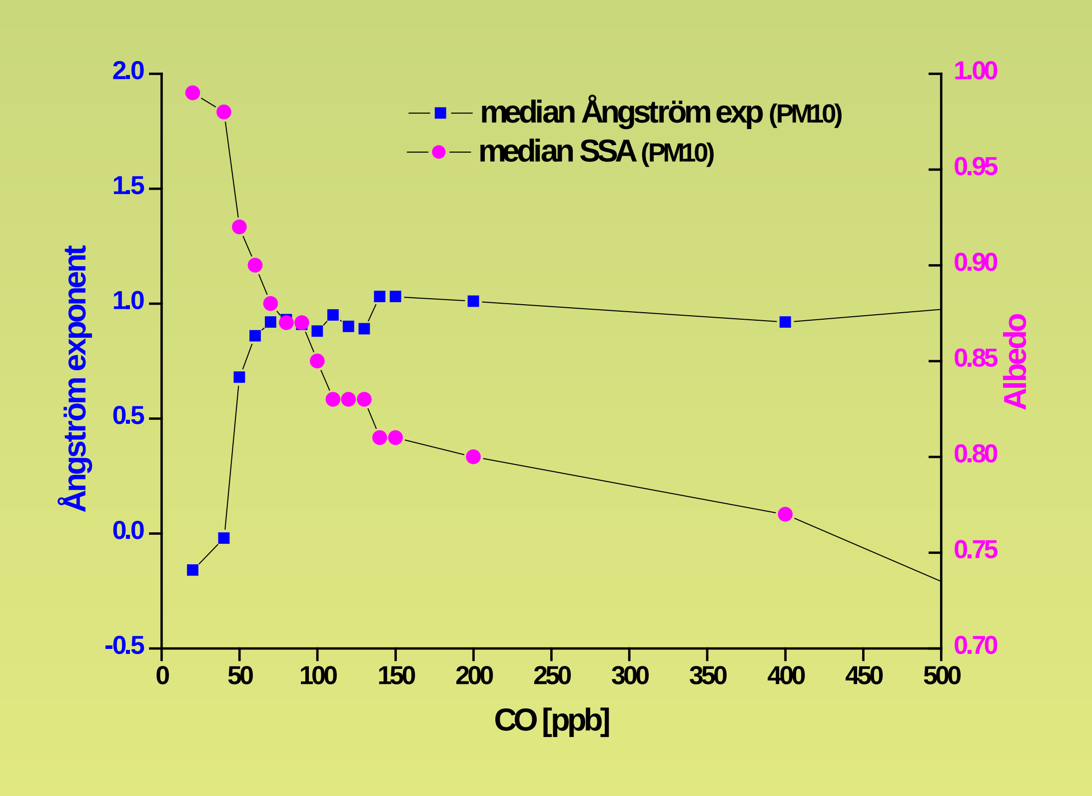




- ❖ Changes in albedo is very sensitive to variations in CO
- ❖ For CO < 50 ppb, albedo corresponds to ~0.97 – 1.0 (particles of mostly of reflective nature)
- ❖ For CO < 130 ppb, albedo ~0.93 – 0.83 (darker particles more absorptive in nature)
- ❖ 3 albedo "ranges" representing (1) clean, marine air (2) mixed urban / continental / biomass (3) urban combustion & biomass burning
- ❖ Backscatter fraction is another indicator of particle size: ratio of $\sigma_{bsp\_G} / \sigma_{sp\_G}$
- ❖ As CO increases above baseline, smaller particle sizes become more prominent

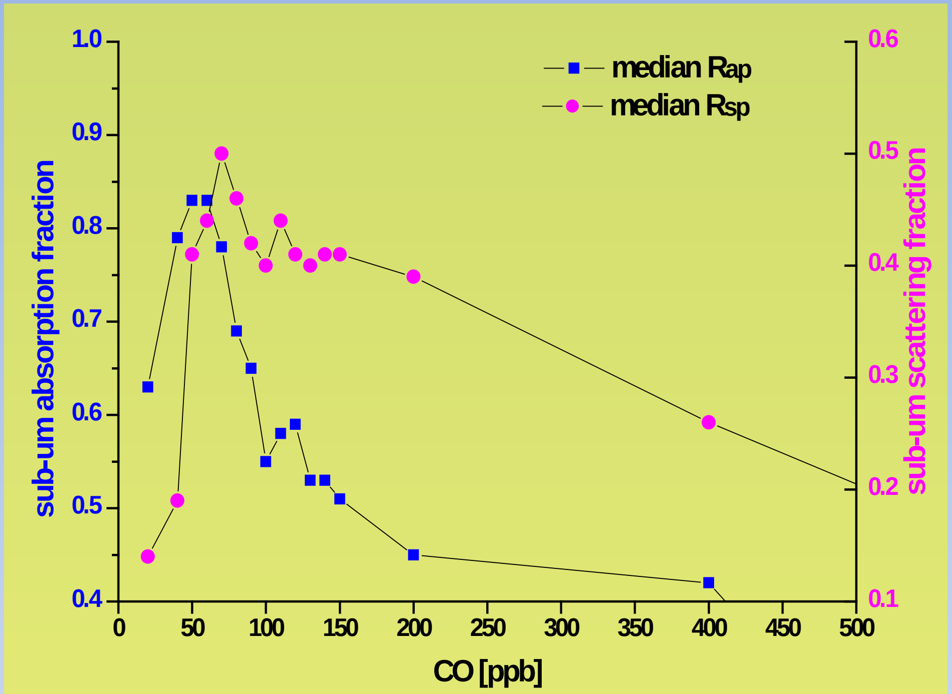
South African Weather Service

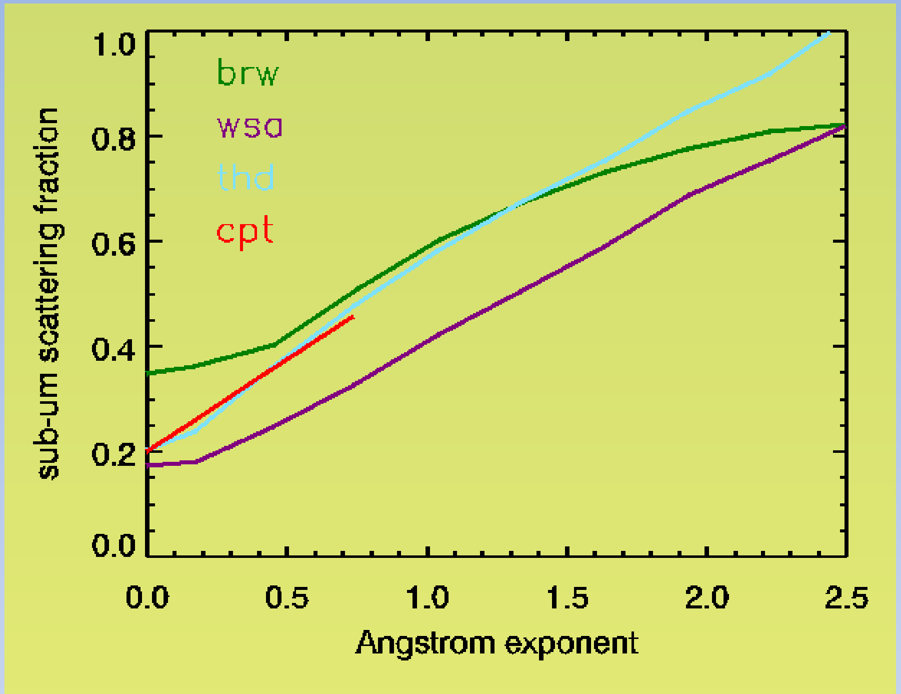
Aerosol optical properties as f(x) of Carbon monoxide distribution (cont.)



- ❖ Changes in Ångström exp is also very sensitive & abrupt when [CO] changes to polluted conditions
- ❖ For CO > 50 ppb, very clear shift from larger particle sizes to smaller sizes
- ❖ At CPT [CO] < 50 ppb ≈ å ≤ 0 and [CO] >100 ppb ≈ å =1
- ❖ Particle size remain fairly constant on [CO] ~100 - 400 ppb; SSA indicate increase in absorptive nature over the same range
- ❖ For the sub10μm data, median å ≈1 associated with a SSA of 0.76 – 0.86

Aerosol optical properties as f(x) of Carbon monoxide distribution (cont.)





- ❖ Sub-µm scattering fraction increases on [CO] ~20 -100 ppb then levels off at 0.4
- ❖ Sub-µm absorption fraction decreases from 0.85 – 0.45 in 70+ ppb [CO] range
- ❖ Comparison of CPT with 3 marine stations (brw=Barrow, Alaska; wsa=Sable island, Nova Scotia; thd=Trinidad head, California).
- ❖ As Rsp increases (more scattering due to sub-um particles) angstrom exponent (10um, red/green wavelength pair) also increases

Summary & Conclusions

- Observed aerosol climatology largely driven by summer – winter wind regimes
- Large range of albedo (ω_0) values for CPT: e.g. continental winter-time total fraction varies between 0.70 – 0.97
- Ångström exp annual cycle clearly reflects the dominance of large, sea salt aerosols in summer months and smaller, combustion related aerosols in winter
- At [CO] above 100 ppb, small particles play a significant role in defining CPT albedo & Ångström exponents
- Complimentary trace gas data (e.g. CO & ^{222}Rn) useful tool in characterizing overall aerosol climatology at Cape Point

THANK YOU

Any questions?